

"CROSS REFERENCE TO RELATED APPLICATION

Not Applicable

STATEMENT REGARDING FEDERALLY SPONSORED

RESEARCH OR DEVELOPMENT

Not Applicable"

and replace it with:

② -- This application is a Continuation-in-Part of U.S. Patent Application Serial No. 08/853,649 filed May 9, 1997, and now pending. --

Remarks

The specification has been changed to claimed priority to 08/853,649, under 35 U.S.C. §120. Serial No. 08/853,649 (Inventor Eric J. Bergman) is pending (allowed) before Examiner Goudreau, AU 1763. The claims as allowed in 08/853,649 are enclosed.

Respectfully submitted,

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Serial No. 08/853,649

**Collated Allowed Claims as of
November 16, 2000 Notice of Allowance**

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1. A method for cleaning a surface of a semiconductor article, comprising:
contacting the surface with an oxidizing solution;
removing the surface from contact with the oxidizing solution;
rinsing the surface with a rinsing solution to remove and inhibit further activity of the oxidizing solution; and
exposing the surface to an oxide removal vapor comprising ozone.
2. The method of claim 1 and further comprising drying the surface after the rinsing step and before the exposing step.
3. The method of claim 1 and further comprising drying the surface after the rinsing step and before the exposing step;

and wherein the exposing step is performed without wetting the surface.
4. The method of claim 1 wherein the oxidizing solution comprises sulfuric acid and hydrogen peroxide.

5. The method of claim 1 wherein the oxidizing solution comprises sulfuric acid, hydrogen peroxide and water.

6. The method of claim 1 wherein the oxidizing solution comprises sulfuric acid, hydrogen peroxide, water and ozone.

7. The method of claim 1 wherein the oxidizing solution comprises ozone.

8. The method of claim 1 wherein the oxidizing solution comprises ozone, and provided that the oxidizing solution does not comprise sulfuric acid.

9. The method of claim 1 wherein the oxidizing solution is a solution of ozone in water.

10. The method of claim 1 wherein the oxidizing solution comprises hydrogen chloride.

11. The method of claim 1 wherein the oxidizing solution comprises hydrogen chloride and water.

12. The method of claim 1 wherein the oxidizing solution comprises hydrogen chloride and ozone.

13. The method of claim 1 wherein the oxidizing solution comprises hydrogen chloride, water and ozone.

14. The method of claim 1 wherein the oxide removal vapor further comprises hydrogen fluoride vapor.

15. The method of claim 1 wherein the oxide removal vapor further comprises hydrogen fluoride vapor.

16. The method of claim 1 wherein the oxide removal vapor further comprises hydrogen fluoride vapor and isopropyl alcohol vapor.

17. The method of claim 1 wherein the oxide removal vapor further comprises hydrogen fluoride vapor and water vapor.

18. The method of claim 1 wherein the oxide removal vapor further comprises hydrogen fluoride vapor, isopropyl alcohol vapor and water vapor.

19. The method of claim 1 wherein the oxide removal vapor further comprises hydrogen fluoride vapor, isopropyl alcohol vapor and an acid vapor other than hydrogen fluoride vapor.

20. The method of claim 1 wherein the oxide removal vapor further comprises hydrogen fluoride vapor, isopropyl alcohol vapor and hydrogen chloride vapor.

21. The method of claim 1 wherein the oxide removal vapor further comprises hydrogen fluoride vapor, isopropyl alcohol vapor, hydrogen chloride vapor and water vapor.

24. The method of claim 1 and further comprising rotating the semiconductor article while performing at least one of said contacting, rinsing or exposing steps.

25. The method of claim 1 and further comprising rotating the semiconductor article while performing at least one of said contacting, rinsing or exposing steps;

and wherein at least one of said contacting or rinsing steps is performed by spraying liquids upon the surface.

26. A method for cleaning a surface of a silicon semiconductor article, comprising:

contacting the surface with an oxidizing solution which includes sulfuric acid and ozone;
rinsing the surface with a rinsing solution to remove and inhibit further activity of the oxidizing solution;

drying the surface;

exposing the surface after said drying step to an oxide removal vapor which comprises at least hydrogen fluoride vapor, to remove semiconductor oxide from the surface.

27. The method of claim 26 wherein the exposing step is performed without wetting the surface.

28. The method of claim 26 wherein the contacting step is performed at a temperature in the range from about 50°C to about 150°C.

29. The method of claim 26 wherein the contacting step is performed at a temperature in the range from about 90°C to about 140°C.

30. The method of claim 26 wherein the oxidizing solution further comprises hydrogen peroxide.

31. The method of claim 26 wherein the oxidizing solution further comprises hydrogen peroxide and water.

32. The method of claim 26 wherein the rinsing solution is water.

33. The method of claim 26 wherein the oxide removal vapor further comprises isopropyl alcohol vapor.

34. The method of claim 26 wherein the oxide removal vapor further comprises water vapor.

35. The method of claim 26 wherein the oxide removal vapor further comprises isopropyl alcohol vapor and water vapor.

36. The method of claim 26 wherein the oxide removal vapor further comprises isopropyl alcohol vapor and an acid vapor other than hydrogen fluoride vapor.

37. The method of claim 26 wherein the oxide removal vapor further comprises isopropyl alcohol vapor and hydrogen chloride vapor.

38. The method of claim 26 wherein the oxide removal vapor further comprises isopropyl alcohol vapor, hydrogen chloride vapor and water vapor.

39. The method of claim 26 wherein the oxide removal vapor comprises hydrogen fluoride vapor and ozone.

40. The method of claim 26 wherein the oxide removal vapor comprises hydrogen fluoride vapor, water vapor and ozone.

41. The method of claim 26 wherein the oxide removal vapor comprises hydrogen fluoride vapor, isopropyl alcohol vapor and ozone.

42. The method of claim 26 and further comprising rotating the semiconductor article while performing at least one of said contacting, rinsing, drying, or exposing steps.

43. The method of claim 26 and further comprising rotating the semiconductor article while performing at least one of said contacting, rinsing, drying, or exposing steps;

and wherein at least one of said contacting or rinsing steps is performed by spraying liquids upon the surface.

44. A method for cleaning a surface of a silicon semiconductor article, comprising:
contacting the surface with an oxidizing solution which includes hydrogen chloride acid and ozone;

rinsing the surface with a rinsing solution to remove and inhibit further activity of the oxidizing solution;

drying the surface;

exposing the surface after said drying step to an oxide removal vapor which comprises at least hydrogen fluoride vapor, to remove semiconductor oxide from the surface.

45. The method of claim 44 wherein the exposing step is performed without wetting the surface.

46. The method of claim 44 wherein the oxidizing solution further comprises water.

47. The method of claim 44 wherein the rinsing solution is water.

48. The method of claim 44 wherein the oxide removal vapor comprises hydrogen fluoride vapor and isopropyl alcohol vapor.

49. The method of claim 44 wherein the oxide removal vapor comprises hydrogen fluoride vapor and water vapor.

50. The method of claim 44 wherein the oxide removal vapor comprises hydrogen fluoride vapor, isopropyl alcohol vapor and water vapor.

51. The method of claim 44 wherein the oxide removal vapor comprises hydrogen fluoride vapor, isopropyl alcohol vapor and an acid vapor other than hydrogen fluoride vapor.

52. The method of claim 44 wherein the oxide removal vapor comprises hydrogen fluoride vapor, isopropyl alcohol vapor and hydrogen chloride vapor.

53. The method of claim 44 wherein the oxide removal vapor comprises hydrogen fluoride vapor, isopropyl alcohol vapor, hydrogen chloride vapor and water vapor.

54. The method of claim 44 wherein the oxide removal vapor comprises hydrogen fluoride vapor and ozone.

55. The method of claim 44 wherein the oxide removal vapor comprises hydrogen fluoride vapor, water vapor and ozone.

56. The method of claim 44 wherein the oxide removal vapor comprises hydrogen fluoride vapor, isopropyl alcohol vapor and ozone.

57. The method of claim 44 and further comprising rotating the semiconductor article while performing at least one of said contacting, rinsing, drying, or exposing steps.

58. The method of claim 44 and further comprising rotating the semiconductor article while performing at least one of said contacting, rinsing, drying, or exposing steps;
and wherein at least one of said contacting or rinsing steps is performed by spraying liquids upon the surface.

59. A method for cleaning a surface of a semiconductor article, comprising:
contacting the surface with an oxidizing solution containing ozone;
rinsing the oxidizing solution from the surface to remove and inhibit further activity of the oxidizing solution;
exposing the surface to an oxide removal vapor which removes semiconductor oxide from the surface.

60. The method of claim 59 wherein the exposing step is performed without wetting the surface.

61. The method of claim 59 wherein the oxidizing solution further comprises sulfuric acid and hydrogen peroxide.

62. The method of claim 59 wherein the oxidizing solution further comprises sulfuric acid, hydrogen peroxide and water.

64. The method of claim 59 wherein the oxidizing solution comprises sulfuric acid and ozone.

65. The method of claim 59 wherein the oxidizing solution is a solution of ozone in water.

66. The method of claim 59 wherein the oxidizing solution further comprises hydrogen chloride.

67. The method of claim 59 wherein the oxidizing solution further comprises hydrogen chloride and water.

70. The method of claim 59 wherein the rinsing solution is water.

71. The method of claim 59 wherein the oxide removal vapor comprises hydrogen fluoride vapor.

72. The method of claim 59 wherein the oxide removal vapor comprises hydrogen fluoride vapor and isopropyl alcohol vapor.

73. The method of claim 59 wherein the oxide removal vapor comprises hydrogen fluoride vapor and water vapor.
74. The method of claim 59 wherein the oxide removal vapor comprises hydrogen fluoride vapor, isopropyl alcohol vapor and water vapor.
75. The method of claim 59 wherein the oxide removal vapor comprises hydrogen fluoride vapor, isopropyl alcohol vapor and an acid vapor other than hydrogen fluoride vapor.
76. The method of claim 59 wherein the oxide removal vapor comprises hydrogen fluoride vapor, isopropyl alcohol vapor and hydrogen chloride vapor.
77. The method of claim 59 wherein the oxide removal vapor comprises hydrogen fluoride vapor, isopropyl alcohol vapor, hydrogen chloride vapor and water vapor.
78. The method of claim 59 wherein the oxide removal vapor comprises ozone.
79. The method of claim 59 wherein the oxide removal vapor comprises hydrogen fluoride vapor, water vapor and ozone.
80. The method of claim 59 and further comprising rotating the semiconductor article while performing at least one of said contacting, rinsing, drying, or exposing steps.

81. The method of claim 59 and further comprising rotating the semiconductor article while performing at least one of said contacting, rinsing, drying, or exposing steps;

and wherein at least one of said contacting or rinsing steps is performed by spraying liquids upon the surface.

86. A method for cleaning a surface of a semiconductor article, comprising exposing the surface to an oxide removal vapor which comprises hydrogen fluoride vapor and ozone vapor.

87. A method according to claim 86 wherein the oxide removal vapor further comprises water.

91. The method of claim 59 wherein the ozone is injected into the oxidizing solution and is dissolved in the solution when the surface is contacted by the oxidizing solution.

92. A method for cleaning a semiconductor article, comprising the steps of:
contacting the article with an oxidizing solution;
rinsing the article; and
exposing the article to a vapor comprising ozone.

98. A method for cleaning a surface of a semiconductor article, comprising the steps of:

- loading the semiconductor article into a chamber;
- providing a heated liquid solution onto the surface of the article within the chamber, the solution comprising deionized water and hydrogen chloride;
- providing ozone into the chamber; and
- rotating the article within the chamber with the heated liquid solution on the surface of the article.

101. The method of claim 92 where the solution comprises de-ionized water.

102. The method of claim 92 where the solution is heated to a temperature between room temperature and 200°C.

103. The method of claim 92 where the solution is heated to a temperature between 50-90°C.

104. The method of claim 92 where the article is rotated at 200-2000rpm.

END